CLAIMS

1. Apparatus for use with a steerable catheter that includes a thumb control adapted to control a deflection of a distal tip of the catheter, the apparatus comprising a robot, comprising:

an end-effector, adapted to be coupled to the thumb control; and

a controller, adapted to drive the end-effector to deflect the distal tip by manipulating the thumb control.

2. The apparatus according to claim 1, wherein the controller is adapted to drive the end-effector to deflect the distal tip by moving the thumb control longitudinally with respect to a longitudinal axis of the catheter.

3. The apparatus according to claim 1,

wherein the catheter includes a handle, adapted to control a roll of the distal tip,

wherein the robot comprises a handle end-effector, adapted to be coupled to the handle, and

wherein the controller is adapted to drive the handle end-effector to roll the distal tip by manipulating the handle.

4. The apparatus according to claim 1,

wherein the catheter includes a handle, adapted to advance and withdraw the catheter,

wherein the robot comprises a handle end-effector, adapted to be coupled to the handle, and

wherein the controller is adapted to drive the handle end-effector to perform, by manipulating the handle, at least one action selected from the list consisting of: advancing the catheter and withdrawing the catheter.

5. The apparatus according to claim 1,

comprising a computer pointing device, adapted to receive an indication of a desired position of the distal tip,

wherein the catheter includes a position sensor, fixed in a vicinity of the distal tip, and adapted to generate a position signal, and

wherein the controller is adapted to receive the position signal, and, responsive thereto, to drive the end-effector to position the distal tip at the desired position.

6. Apparatus comprising:

a steerable catheter, comprising a thumb control, which is adapted to control a deflection of a distal tip of the catheter; and

a robot, comprising:

an end-effector, adapted to be coupled to the thumb control; and

a controller, adapted to drive the end-effector to deflect the distal tip by manipulating the thumb control.

7. Apparatus for use with a steerable catheter that includes controls adapted to control a deflection of a distal tip of the catheter, which controls are generally optimized for manipulation by a human hand, the apparatus comprising a robot, comprising:

at least one end-effector, adapted to be coupled to at least a portion of the controls; and

a controller, adapted to drive the at least one end-effector to deflect the distal tip by inducing motion of the portion of the controls that generally mimics motion of the portion of the controls induced when a human hand manipulates the controls.

8. The apparatus according to claim 7, wherein the controller is adapted to drive the end-effector to deflect the distal tip by moving the portion of the controls longitudinally with respect to a longitudinal axis of the catheter.

9. The apparatus according to claim 7,

wherein the controls are adapted to control a roll of the distal tip,

wherein the robot comprises a roll end-effector, adapted to be coupled to the controls, and

wherein the controller is adapted to drive the roll end-effector to roll the distal tip by inducing motion of the controls that generally mimics motion of the controls induced when a human hand manipulates the controls.

10. The apparatus according to claim 7,

wherein the controls are adapted to advance and withdraw the catheter,

wherein the robot comprises a longitudinal motion end-effector, adapted to be coupled to the controls, and

wherein the controller is adapted to drive the longitudinal motion end-effector to perform, by inducing motion of the controls that generally mimics motion of the controls induced when a human hand manipulates the controls, at least one action selected from the list consisting of: advancing the catheter and withdrawing the catheter.

11. The apparatus according to claim 7,

comprising a computer pointing device, adapted to receive an indication of a desired position of the distal tip,

wherein the catheter includes a position sensor, fixed in a vicinity of the distal tip, and adapted to generate a position signal, and

wherein the controller is adapted to receive the position signal, and, responsive thereto, to drive the end-effector to position the distal tip at the desired position.

12. Apparatus comprising:

a steerable catheter, comprising controls adapted to control a deflection of a distal tip of the catheter, which controls are generally optimized for manipulation by a human hand; and

a robot, comprising:

at least one end-effector, adapted to be coupled to at least a portion of the controls; and

a controller, adapted to drive the at least one end-effector to deflect the distal tip by inducing motion of the portion of the controls that generally mimics motion of the portion of the controls induced when a human hand manipulates the controls.

13. Apparatus comprising:

a steerable catheter, comprising:

a distal tip adapted to be controllably deflectable in no more than two directions for any given rotation of the distal tip, such that a set of all points to which the tip can be deflected at the given rotation forms a deflection curve for the given rotation; and

a position sensor, fixed in a vicinity of the distal tip, and adapted to generate a position signal;

a robot, adapted to manipulate a proximal end of the catheter; and

a control unit, adapted to:

receive the position signal, and

position the distal tip at a target by driving the robot to:

position the distal tip in a vicinity of the target, responsive to the position signal,

rotate the proximal end in order to cause the distal tip to roll to a rotation the deflection curve of which includes the target, the rotation determined responsive to the position signal, and

deflect the distal tip along the deflection curve to the target.

14. The apparatus according to claim 13, wherein the distal tip is adapted to be controllably deflected in no more than one direction for the given rotation of the distal tip.

15. The apparatus according to claim 13, wherein the control unit is adapted to position the distal tip in the vicinity of the target by positioning the distal tip so that the deflection curve of at least one rotation of the distal tip includes the target.

16. The apparatus according to claim 13, comprising a computer pointing device, adapted to receive an indication of a position of the target, wherein the control unit is adapted to drive the robot to position the distal tip at the position of the target, responsive to the position signal.

17. The apparatus according to claim 13, wherein the position sensor is adapted to generate the position signal having six dimensions of position and orientation information.

18. Apparatus comprising:

a steerable catheter having a distal tip, the catheter comprising a position sensor, fixed in a vicinity of the distal tip, and adapted to generate a position signal;

a robot, adapted to be coupled to a proximal end of the catheter; and

a control unit, adapted to:

drive the robot to apply rotation to the proximal end of the catheter,

receive the position signal,

responsive to the position signal, determine a roll of the distal tip, and

responsive to a determination that the roll lags the rotation, drive the robot to move a portion of the proximal end of the catheter.

19. The apparatus according to claim 18, wherein the control unit is adapted to drive the robot to move the portion of the proximal end of the catheter to perform at least one action selected from the list consisting of: straightening the distal tip and deflecting the distal tip.

20. The apparatus according to claim 18, wherein the control unit is adapted to drive the robot to move the portion of the proximal end of the catheter to effect translational back and forth motion of the distal tip.

21. The apparatus according to claim 18, wherein the control unit is adapted to drive the robot to move the portion of the proximal end of the catheter to perform at least one action selected from the list consisting of: advancing the distal tip and withdrawing the distal tip.

22. The apparatus according to claim 18, wherein the position sensor is adapted to generate the position signal having six dimensions of position and orientation information.

23. The apparatus according to claim 18, wherein the control unit is adapted to move the portion of the proximal end of the catheter to jiggle the distal tip.

24. The apparatus according to claim 23, wherein the control unit is adapted to jiggle the distal tip by rotating the proximal end of the catheter.

25. A method for use with a steerable catheter that includes a thumb control adapted to control a deflection of a distal tip of the catheter, the method comprising:

coupling a robotic end-effector to the thumb control; and

driving the end-effector to deflect the distal tip by manipulating the thumb control.

26. The method according to claim 25, wherein manipulating the thumb control comprises moving the thumb control longitudinally with respect to a longitudinal axis of the catheter.

27. The method according to claim 25, wherein the catheter includes a handle, adapted to control a roll of the distal tip, and comprising:

coupling a handle end-effector to the handle; and

driving the handle end-effector to roll the distal tip by manipulating the handle.

28. The method according to claim 25, wherein the catheter includes a handle, adapted to advance and withdraw the catheter, and comprising:

coupling a handle end-effector to the handle; and

driving the handle end-effector to perform, by manipulating the handle, at least one action selected from the list consisting of: advancing the catheter and withdrawing the catheter.

29. The method according to claim 25, comprising:

receiving an indication of a desired position of the distal tip;

receiving a position signal generated from a vicinity of the distal tip; and

driving the end-effector to position the distal tip at the desired position, responsive to the position signal.

30. A method for use with a steerable catheter that includes controls adapted to control a deflection of a distal tip of the catheter, which controls are generally optimized for manipulation by a human hand, the method comprising:

coupling at least one robotic end-effector to at least a portion of the controls; and

driving the at least one end-effector to deflect the distal tip by inducing motion of the portion of the controls that generally mimics motion of the portion of the controls induced when a human hand manipulates the controls.

31. The method according to claim 30, wherein inducing the motion of the portion of the controls comprises moving the portion of the controls longitudinally with respect to a longitudinal axis of the catheter.

32. The method according to claim 30, wherein the controls are adapted to control a roll of the distal tip, and comprising:

coupling a roll end-effector to the controls; and

driving the roll end-effector to roll the distal tip by inducing motion of the controls that generally mimics motion of the controls induced when a human hand manipulates the controls.

33. The method according to claim 30, wherein the controls are adapted to advance and withdraw the catheter, and comprising:

coupling a longitudinal motion end-effector to the controls; and

driving the longitudinal motion end-effector to perform, by inducing motion of the controls that generally mimics motion of the controls induced when a human hand manipulates the controls, at least one action selected from the list consisting of: advancing the catheter and withdrawing the catheter.

34. The method according to claim 30, comprising:

receiving an indication of a desired position of the distal tip;

receiving a position signal generated from a vicinity of the distal tip; and

driving the end-effector to position the distal tip at the desired position, responsive to the position signal.

35. A method for use with a steerable catheter having a distal tip adapted to be controllably deflectable in no more than two directions for any given rotation of the distal tip, such that a set of all points to which the tip can be deflected at the given rotation forms a deflection curve for the given rotation, the method comprising:

receiving a position signal from a vicinity of the distal tip; and

robotically positioning the distal tip at a target by:

robotically positioning the distal tip in a vicinity of the target, responsive to the position signal,

robotically rotating the proximal end in order to cause the distal tip to roll to a rotation the deflection curve of which includes the target, the rotation determined responsive to the position signal, and

robotically deflecting the distal tip along the deflection curve to the target.

36. The method according to claim 35, wherein robotically positioning the distal tip in the vicinity of the target comprises robotically positioning the distal tip so that the deflection curve of at least one rotation of the distal tip includes the target.

37. The method according to claim 35, comprising receiving an indication of a position of the target, wherein robotically deflecting the distal tip comprises robotically deflecting the distal tip to the position of the target, responsive to the position signal.

38. The method according to claim 35, wherein receiving the position signal comprises receiving the position signal, the position signal having six dimensions of position and orientation information.

39. A method for use with a steerable catheter having a distal tip and a proximal end, the method comprising:

robotically rotating the proximal end of the catheter;

receiving a position signal from a vicinity of the distal tip of the catheter;

responsive to the position signal, determining a roll of the distal tip; and

responsive to a determination that the roll lags the rotation, robotically moving a portion of the proximal end of the catheter.

40. The method according to claim 39, wherein robotically moving the portion of the proximal end of the catheter comprises robotically performing at least one action selected from the list consisting of: straightening the distal tip and deflecting the distal tip.

41. The method according to claim 39, wherein robotically moving the portion of the proximal end of the catheter comprises robotically translating the distal tip back and forth.

42. The method according to claim 39, wherein robotically moving the portion of the proximal end of the catheter comprises robotically performing at least one action selected from the list consisting of: advancing the distal tip and withdrawing the distal tip.

43. The method according to claim 39, wherein receiving the position signal comprises receiving the position signal, the position signal having six dimensions of position and orientation information.

44. The method according to claim 39, wherein robotically moving the portion of the proximal end of the catheter comprises robotically jiggling the distal tip.

45. The method according to claim 44, wherein robotically jiggling the distal tip comprises robotically rotating the proximal end of the catheter.